

Figure 18: Breakdown of TBL NPV for Pervious Pavers

Table 17: Pervious Pavers Relative Results Compared to Concrete with 95% CI (\$/1,000 sq ft)

Impact Type	Cost/Benefit	Mean Value	95% Confidence Interval		
Financial	Capital Expenditures	-\$7,180	-\$11,670	to	-\$2,323
Financial	Operations and Maintenance	-\$676	-\$1,019	to	-\$381
Financial	CapEx on Additional Detention	\$24	\$9	to	\$39
Financial	O&M on Additional Detention	\$6	\$0	to	\$11
Financial	CapEx on Additional Piping	\$505	\$403	to	\$642
Financial	O&M on Additional Piping	\$76	\$45	to	\$110
Financial	Replacement Costs	-\$4,454	-\$9,355	to	-\$157
Financial	Residual Value of Assets	\$633	-\$832	to	\$2,671
Social	Heat Island Effect (Mortality)	-\$55	-\$1,167	to	\$1,057
Social	Heat Island Effect (Morbidity)	\$0	-\$3	to	\$4
Social	Flood Risk	\$481	\$481	to	\$481
Social	Property Value	\$129	\$82	to	\$181
Environmental	Water quality	\$1,912	\$323	to	\$3,963
Environmental	Carbon Emissions from Concrete	\$3,176	\$1,294	to	\$5,771
Environmental	Air Pollution Reduced by Vegetation	\$0	\$0	to	\$0
Environmental	Carbon Reduction by Vegetation	\$0	\$0	to	\$0
Environmental	Air Pollution Reduced by Energy Use	\$0	\$0	to	\$0
Environmental	Carbon Reduction by Energy Use	\$0	\$0	to	\$0
Total	Triple Bottom Line NPV	-\$5,424	-\$21,411	to	\$12,068

3.7 Porous Concrete

Porous concrete generates an estimated \$2,700 (95% confidence interval of -\$8,647 to \$14,938) in triple bottom line net present value over a 50-year time horizon relative to Concrete, with -\$3,200 created through financial impacts, \$800 through social impacts, and \$5,100 through environmental benefits.

Figure 19 shows a waterfall chart of the breakdown of these values. On the chart, blue represents value being created, whereas red represents a cost, relative to concrete. We can see that Porous concrete has a much higher CapEx and replacement cost than Concrete. Varying amounts of value are created across the social and environmental spectrum of impacts, with the most significant being flood risk (\$500), water quality (\$1,900), and avoided carbon emissions from concrete use (\$3,200).

The 95% confidence intervals shown in Table 18 allow us to see the uncertainty in some of these figures. There is a large spread in CapEx (-\$4,358 to \$152), replacement cost (-\$4,079 to \$1,262), as well as water quality (\$323 to \$3,963). When all impacts have been assessed it creates a large spread in overall TBL-NPV of -\$8,647 to \$14,938, indicating that there is a fair possibility of either a positive or negative TBL-NPV compared to Concrete.

Financial	Social	Environmental
-\$3,211	\$814	\$5,098
Triple Bottom Line NPV		\$2,691

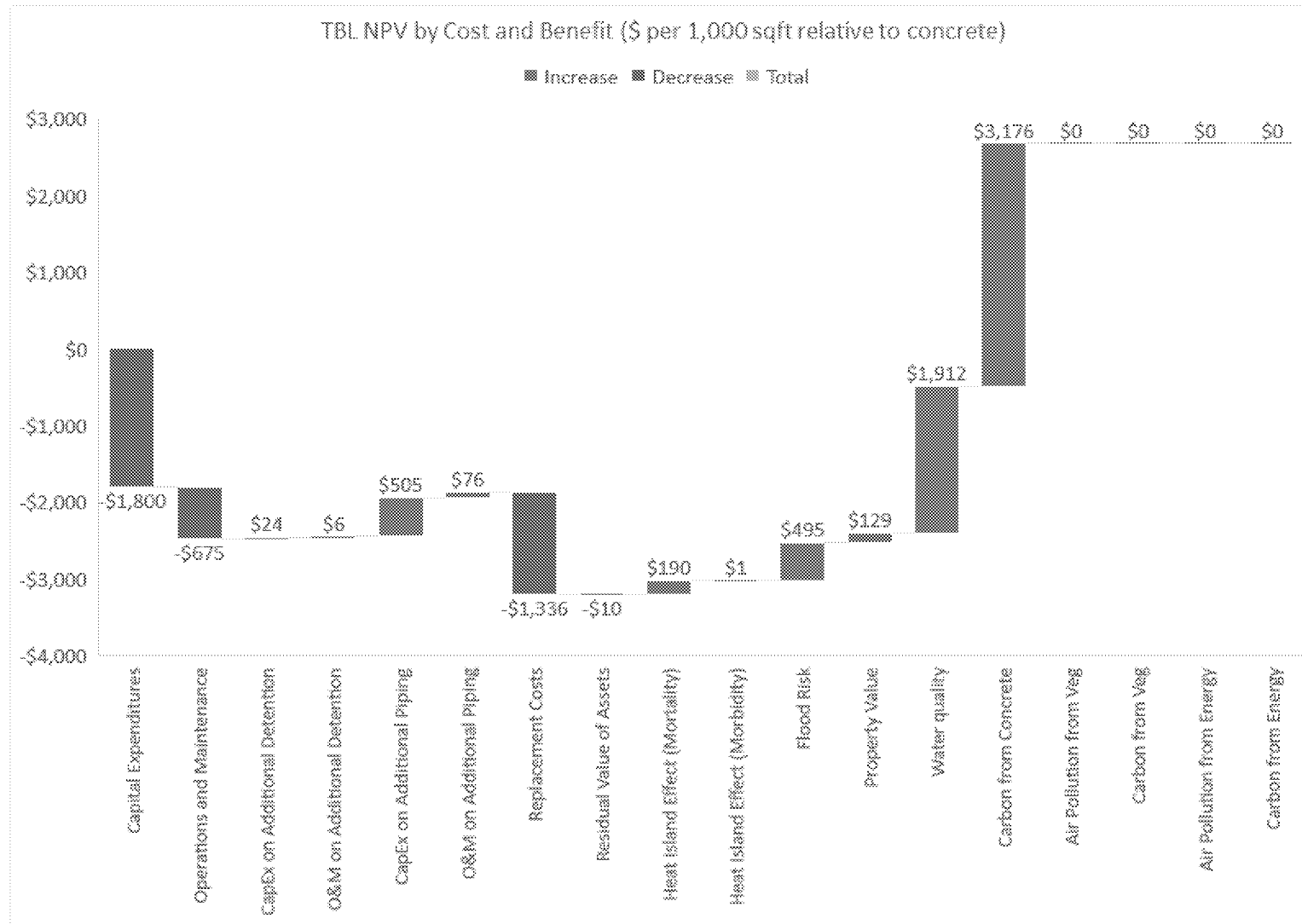


Figure 19: Breakdown of TBL NPV for Porous Concrete

Table 18: Porous Concrete Relative Results Compared to Concrete with 95% CI (\$/1,000 sq ft)

Impact Type	Cost/Benefit	Mean Value	95% Confidence Interval		
Financial	Capital Expenditures	-\$1,800	-\$4,358	to	\$152
Financial	Operations and Maintenance	-\$675	-\$1,015	to	-\$386
Financial	CapEx on Additional Detention	\$24	\$9	to	\$39
Financial	O&M on Additional Detention	\$6	\$0	to	\$11
Financial	CapEx on Additional Piping	\$505	\$403	to	\$642
Financial	O&M on Additional Piping	\$76	\$45	to	\$110
Financial	Replacement Costs	-\$1,336	-\$4,079	to	\$1,262
Financial	Residual Value of Assets	-\$10	-\$845	to	\$1,313
Social	Heat Island Effect (Mortality)	\$190	-\$997	to	\$1,380
Social	Heat Island Effect (Morbidity)	\$1	-\$3	to	\$4
Social	Flood Risk	\$495	\$495	to	\$495
Social	Property Value	\$129	\$81	to	\$180
Environmental	Water quality	\$1,912	\$323	to	\$3,963
Environmental	Carbon Emissions from Concrete	\$3,176	\$1,294	to	\$5,771
Environmental	Air Pollution Reduced by Vegetation	\$0	\$0	to	\$0
Environmental	Carbon Reduction by Vegetation	\$0	\$0	to	\$0
Environmental	Air Pollution Reduced by Energy Use	\$0	\$0	to	\$0
Environmental	Carbon Reduction by Energy Use	\$0	\$0	to	\$0
Total	Triple Bottom Line NPV	\$2,691	-\$8,647	to	\$14,938

3.8 Porous Asphalt

Porous asphalt generates an estimated \$2,200 (95% confidence interval of -\$9,949 to \$15,908) in triple bottom line net present value over a 50-year time horizon relative to Concrete, with -\$2,100 created through financial impacts, -\$800 through social impacts, and \$4,800 through environmental benefits.

Figure 20 shows a waterfall chart of the breakdown of these values. On the chart, blue represents value being created, whereas red represents a cost, relative to concrete. We can see that Porous asphalt has small CapEx and O&M incremental costs, while replacement cost is the main cost driver. Varying amounts of value (as well as dis-benefits) are created across the social and environmental spectrum of impacts, with the most significant being heat island effect (-\$1,400), water quality (\$1,900), and avoided carbon emissions from concrete use (\$3,200).

The 95% confidence intervals shown in Table 19 allow us to see the uncertainty in some of these figures. There is a large spread in CapEx (-\$3,762 to \$2,915), replacement cost (-\$4,857 to \$1,668), as well as water quality (\$323 to \$3,963). When all impacts have been assessed it creates a large spread in overall TBL-NPV of -\$9,949 to \$15,908, indicating that there is a fair possibility of either a positive or negative TBL-NPV compared to Concrete.

Financial	Social	Environmental
-\$2,136	-\$790	\$4,837
Triple Bottom Line NPV		\$2,162

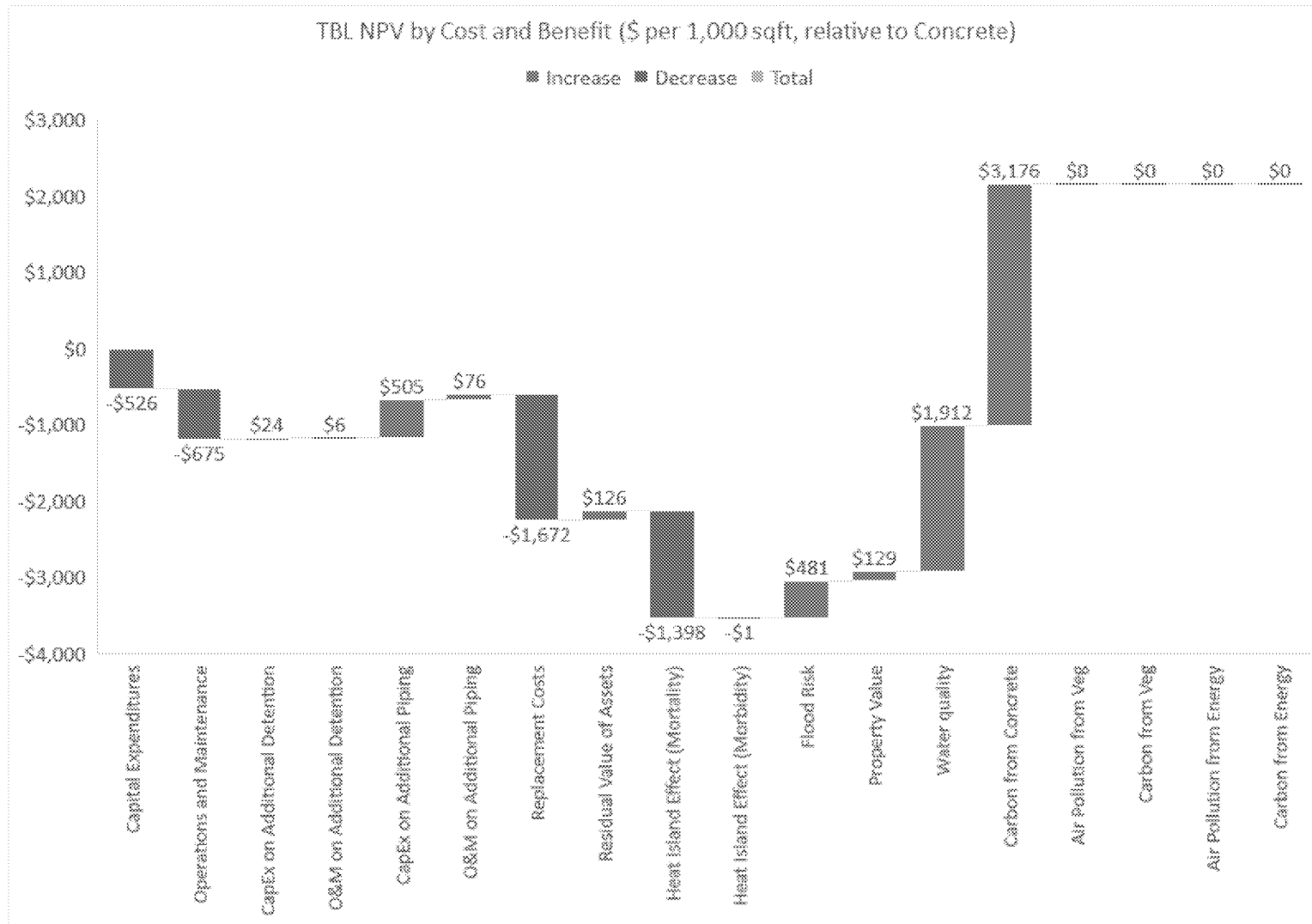


Figure 20: Breakdown of TBL NPV for Porous Asphalt

Table 19: Porous Asphalt Relative Results Compared to Concrete with 95% CI (\$/1,000 sq ft)

Impact Type	Cost/Benefit	Mean Value	95% Confidence Interval		
Financial	Capital Expenditures	-\$526	-\$3,762	to	\$2,915
Financial	Operations and Maintenance	-\$675	-\$1,015	to	-\$386
Financial	CapEx on Additional Detention	\$24	\$9	to	\$39
Financial	O&M on Additional Detention	\$6	\$0	to	\$11
Financial	CapEx on Additional Piping	\$505	\$403	to	\$642
Financial	O&M on Additional Piping	\$76	\$45	to	\$110
Financial	Replacement Costs	-\$1,672	-\$4,857	to	\$1,668
Financial	Residual Value of Assets	\$126	-\$845	to	\$1,233
Social	Heat Island Effect (Mortality)	-\$1,398	-\$2,103	to	-\$718
Social	Heat Island Effect (Morbidity)	-\$1	-\$4	to	\$0
Social	Flood Risk	\$481	\$481	to	\$481
Social	Property Value	\$129	\$82	to	\$178
Environmental	Water quality	\$1,912	\$323	to	\$3,963
Environmental	Carbon Emissions from Concrete	\$3,176	\$1,294	to	\$5,771
Environmental	Air Pollution Reduced by Vegetation	\$0	\$0	to	\$0
Environmental	Carbon Reduction by Vegetation	\$0	\$0	to	\$0
Environmental	Air Pollution Reduced by Energy Use	\$0	\$0	to	\$0
Environmental	Carbon Reduction by Energy Use	\$0	\$0	to	\$0
Total	Triple Bottom Line NPV	\$2,162	-\$9,949	to	\$15,908

4 Project Description (Case Study Sites)

This section describes the three case study sites that are assessed in this report, as well as outlines some of the more detailed design assumptions used in order to generate results within Autocase.

4.1 Sites to be Analyzed

The case study sites analyzed as part of this assessment are:

1. Primera Iglesia is located at 701 S. 1st Street, Phoenix, Arizona. The project installation date was November 2011 and included 15 new trees requiring no supplemental irrigation after the vegetation was established, 4,500 sq ft bioretention basin/rain garden, and curb cuts and cores. The project provided the first Phoenix area GI/LID site demonstration.
2. Glendale Community Center is located at 14075 N. 59th Avenue, Glendale, Arizona. The project installation date was March 2016 and included 8 new trees, two bioretention basins/rain gardens totalling 6,000 sq ft, which is expected to harvest 10,000 gallons of rainwater per year, and curb cuts.
3. A combined project encompassing Central Station, Civic Space Park, and Taylor Mall includes a transit center, public park, and pedestrian improvements generally located around 444 N. Central Avenue in Phoenix. The traditional features include landscaping and one new retention basin² equalling 0.33 acres and one existing retention basin equalling 0.147 acres. GI/LID features include 680 shrubs, 52,000 sq ft of pervious pavers, 13,000 sq ft of vegetated swales with trees, 1,600 sq ft of tree planters, 30,000 sq ft of porous concrete, 243 new trees, and one underground stormwater storage cistern³ with a capacity of 9,600 cf.

Each of these were then compared against a base case to assess their *incremental – or relative* impact.

For Primera Iglesia and Glendale Community Center, the previously existing land cover was used as the base case because both locations were previously developed with no anticipated changes except the GI/LID projects. Therefore, the condition without the GI/LID projects would have remained without alteration. This previously existing land cover at both locations consisted of rocks and compacted, un-vegetated dirt surface. This land cover is not an automated feature type in Autocase, however after speaking to WMG and City staff, it was deemed that the best comparison in Autocase for the existing land cover type was asphalt due to the poor infiltration, water runoff, and heat island impact. Therefore, for Primera and Glendale Community Center, 'Asphalt' was used within Autocase as the base case from which to compare the design. A 20,000 square foot watershed area was included for the case study and comparison base design at Primera Iglesia, and a 25,000 square foot watershed area for both design scenarios at Glendale, in order to represent the surface area that would generate runoff flowing in to each project.

For the Central Station/Civic Space Park/Taylor Mall project, the base case used was concrete. Although the previously existing condition was asphalt parking lot, this case study used an alternate development land cover instead. If GI/LID had not been included as part of the redevelopment, the redevelopment would still have occurred. Therefore, using the previously existing condition as we did for the other two case studies would not have been appropriate. Most the area with GI/LID features constructed would

² A storage area to manage stormwater runoff to prevent flooding and downstream erosion.

³ A rigid device of metal, plastic, or other solid material that captures and stores water from an impervious surface.

likely have been concrete (e.g., pervious pavers and porous concrete at Civic Space Park would likely have been an impervious concrete plaza) and asphalt (e.g., Taylor Mall parking spaces); therefore, the base case selected is a concrete feature equal to the size of the LID features. The base case design also included the new and existing retention basins (0.33 acres and 0.147 acres, respectively), as well as 118 trees to conform to local requirements for retention and tree spacing. A 10.3-acre feature watershed area was included in each analysis to represent the surface area that would generate runoff flowing into the project.

4.2 Project Inputs

This and all further subsections in Section 3 provide information on the specific inputs used in Autocase for each case study and its associated base case comparison design. The specific inputs for the case studies are based on the actual design plans, Google Earth reviews of the finished project, construction cost documents, which are supplemented by SUSTAIN database and the National Stormwater Management Calculator.

4.2.1 Primera Iglesia

4.2.1.1 Base Case

This section outlines the inputs used in Autocase for the base case for Primera Iglesia.



Figure 21: Primera Iglesia (Before)
Source: Watershed Management Group

Table 20: Primera Iglesia Base Case Inputs

	Unit	Expected Value
Name of feature	-	Asphalt
Area	Sq ft	4,480
New or existing?	-	Existing

Notes:

- A feature watershed of 20,000 sq ft was also included as part of the base case.

4.2.1.2 LID Design

This section outlines the inputs used in Autocase for the LID design for Primera Iglesia.



Figure 22: Primera Iglesia (After)
Source: Watershed Management Group

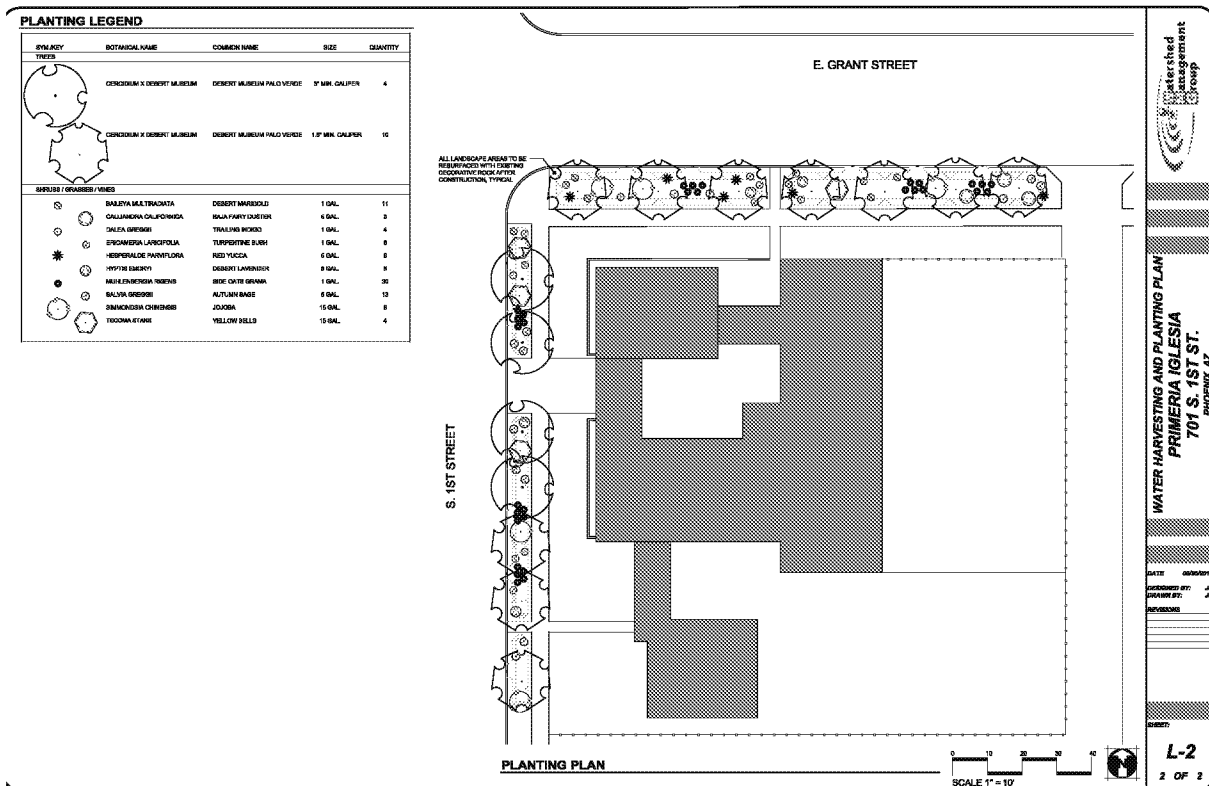


Figure 23: Primera Iglesia Site Plans
Source: Watershed Management Group

Table 21: Primera Iglesia Bioretention Basin Inputs

	Unit	Expected Value
Name of feature		Bioretention/Rain garden
Area	sq ft	4,480
New or existing?		New
Maximum Ponding/Treatment Depth	Inches	6
Depth of Coverage Materials	Inches	3
Percent Empty Space in Material	%	40
Rate of Gray Discharge from Outlet of Feature	-	-
Does this feature allow for infiltration?	Yes/No	Yes
Trees Planted	#	15
Shrubs planted	#	125
Shrubs Average Expected Lifespan	Year	10
Shrubs Max Expected Lifespan	Year	20
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$8,785
Annual O&M	\$	\$542 (Low = \$433, High = \$677)

Notes:

- CapEx come from WMG site costs for Primera Iglesia
- A feature watershed of 20,000 sq ft was also included as part of the design case.
- O&M costs are from Watershed Management Group estimates based on \$120/1,000 sq ft at a rate of \$75/hr.

4.2.2 Glendale Community Center

4.2.2.1 Base Case

This section outlines the inputs used in Autocase for the base case for Glendale Community Center.



Figure 24: Glendale Community Center (Before)
Source: Watershed Management Group

Table 22: Glendale Community Center Base Case Inputs

	Unit	Design case
Name of feature	-	Asphalt
Area	Sq ft	6,000
New or existing?	-	Existing

Notes:

- A feature watershed of 25,000 sq ft was also included as part of the base case.
- Asphalt was chosen as the Base Case feature type in Autocase, due to the porosity and solar absorption properties of the existing features.

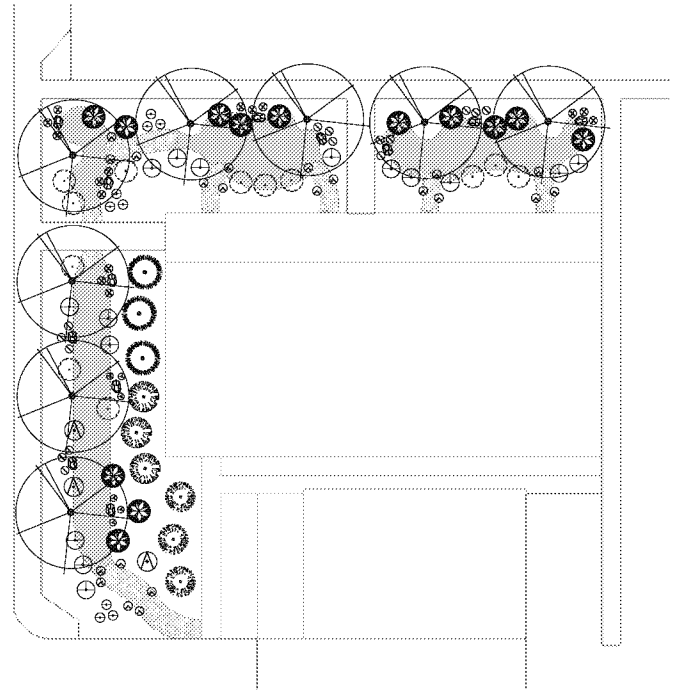
4.2.2.2 LID Design

This section outlines the inputs used in Autocase for the LID design for Glendale Community Center.

SYM KEY	BOTANICAL NAME	COMMON NAME	SIZE	QUANTITY	EMITTER (PER PLANT)	E. SIZE (GPH)	ZONE
TREES							
	Chilopsis linearis	Desert Willow	15 GAL.	8	4	2	TREE
SHRUBS / GRASSES							
	Hyssopus emoryi	Desert Lavender	5 GAL.	3	2	1	SHRUB
	Sarcocolla chrysensis	Jalisco	5 GAL.	3	2	1	SHRUB
	Larrea tridentata	Creosote	5 GAL.	3	2	1	SHRUB
	Calliandra eriophylla	Pink Fairy Duster	5 GAL.	13	2	1	SHRUB
	Judicia californica	Chaparral	5 GAL.	12	2	1	SHRUB
	Viguiera parviflora	Oddeneye	5 GAL.	15	2	1	SHRUB
	Eriogonum fasciculatum	Bridlebrush	1 GAL.	3	2	1	SHRUB
	Baccharis multiflora	Desert Marigold	1 GAL.	15	2	1	SHRUB
	Nerangium leucanthum	Blackford Daisy	1 GAL.	15	2	1	SHRUB
	Acropteron subulata	Desert Milkweed	5 GAL.	9	2	1	SHRUB
	Pandanus exoni	Firecracker Pendleton	1 GAL.	6	2	1	SHRUB
	Bouteloua curtipendula	Sideoats Grama	1 GAL.	21	2	1	SHRUB
SURFACE MATERIALS							
	Boulders Surface Select	2 TON					
	Rip-Rap 3"-12" (Palomero Gold)	9 TON					
	Not Shown	Decorative Gravel (Palomero Gold)	32 TON				

NOTES

EXISTING DECORATIVE ROCK, RIVER ROCK, AND LANDSCAPE DEBRIS TO BE REMOVED FROM SITE.
 EXISTING VEGETATION TO BE REMOVED FROM SITE IF NOT MARKED TO REMAIN.
 EXCAVATION OF RAINWATER HARVESTING FEATURE TO BE MINIMAL AS SITE IS LOCATED IN EXISTING RETENTION BASIN.
 LANDSCAPE AREA ADJACENT TO WALKWAYS TO BE GRADED 3" BELOW HARDSCAPE TOP SURFACE TO ALLOW FOR 2" OF SURFACE COVER.
 EXCAVATED SOIL NOT USED TO CREATE BERMS TO BE REMOVED FROM SITE.
 3"-12" RIP-RAP TO BE USED FOR EROSION CONTROL IN AREAS AS SHOWN ON DRAWING.
 LANDSCAPE AREA TO BE RESURFACED WITH 2" LAYER OF DECORATIVE GRAVEL AFTER CONSTRUCTION.
 TREES TO BE PLANTED A MINIMUM OF 20' AWAY FROM ANY BUILDING.



GRADING AND PLANTING PLAN



Figure 25: Glendale Site Plans (draft design)
 Source: Watershed Management Group



Figure 26: Glendale Community Center (After)
 Source: Watershed Management Group

Table 23: Glendale Community Center Bioretention Basin Inputs

	Unit	Design case
Name of feature		Bioretention/Rain garden
Area	sq ft	6,000
New or existing?		New
Maximum Ponding/Treatment Depth	Inches	6
Depth of Coverage Materials	Inches	3
Percent Empty Space in Material	%	40
Rate of Gray Discharge from Outlet of Feature	-	-
Does this feature allow for infiltration?	Yes/No	Yes
Trees Planted	#	8
Shrubs planted	#	128
Shrubs Average Expected Lifespan	Year	10
Shrubs Max Expected Lifespan	Year	20
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$14,100
Annual O&M	\$	\$726 (Low = \$581, High = \$907)

Notes:

- A feature watershed of 25,000 sq ft was also included as part of the design case.
- CapEx and O&M costs come from WMG site costs for Primera iglesia.
- O&M costs are from Watershed Management Group estimates based on \$120/1,000 sq ft at a rate of \$75/hr.
- Numbers here differ to the design schematic as this was based on as-built measurements and costs.

4.2.3 Central Station/Civic Space Park/Taylor Mall

4.2.3.1 Base Case

This section outlines the inputs used in Autocase for the base case for Central Station/Civic Space Park/Taylor Mall.



Figure 27: Central Station/Civic Space Park/Taylor Mall project area (before, circa 2005)

Table 24: Central/Civic/Taylor Base Case Inputs: Trees

	Unit	Expected Value
Name of feature		Additional Trees
New or existing?		New
Number of new trees being planted	#	118
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$69,738 (Low = \$18,880, High = \$87,173)
Annual O&M	\$	\$1,841 (Low = \$1,381, High = \$2,301)

Notes:

- The base case also includes a feature watershed of 10.3 acres.
- CapEx = \$591.00 per tree taken from Taylor Mall 100% Plan Model. Low = SUSTAIN, High = Local +25%
- O&M = \$15.60 per tree. Watershed Management Group based \$160/1,000 sq ft at a rate of \$100 per hour (instead of \$75/hr, as trees are costlier) and assuming each tree is 9 square meters. Low/High = +/- 25%.

Table 25: Central/Civic/Taylor Base Case Inputs: Concrete

	Unit	Expected Value
Name of feature		Concrete
Area	Acre	2.21
New or existing?		New
Depth of coverage material	Inches	3
Capital expenditure	\$	\$554,622 (Low = \$434,052, High = \$675,192)
Annual O&M	\$	\$0

Notes:

- CapEx and O&M source are City of Phoenix Streets department for per-1,000 sq ft cost estimates.

Table 26: Central/Civic/Taylor Base Case Inputs: New Retention Basin

	Unit	Design case
Name of feature		New Retention basin
Area	Acre	0.33
New or existing?		New
Maximum Ponding/Treatment Depth	Inches	12
Rate of Gray Discharge from Outlet of Feature	-	-
Minimum Permanent Depth	Inches	12
Capital Expenditure	\$	\$166,029 (Low = \$61,237, High = \$326,452)
Annual O&M	\$	\$431 (Low = \$216, High = \$862)
Notes:		
<ul style="list-style-type: none"> CapEx = \$4,260 per cu ft and includes excavation and landscaping. CapEx and O&M are from the National Stormwater Management Calculator. 		

Table 27: Central/Civic/Taylor Base Case Inputs: Existing Retention Basin

	Uni	Expected Value
Name of feature		Existing Retention basin
Area	Acre	0.145
New or existing?		Existing
Maximum Ponding/Treatment Depth	Inches	36
Rate of Gray Discharge from Outlet of Feature	-	-
Minimum Permanent Depth	Inches	36
Notes:		
<ul style="list-style-type: none"> This already exists on the site so there is no incremental cost with this. 		

4.2.3.2 LID Design

This section outlines the inputs used in Autocase for the LID design for Central Station/Civic Space Park/Taylor Mall.

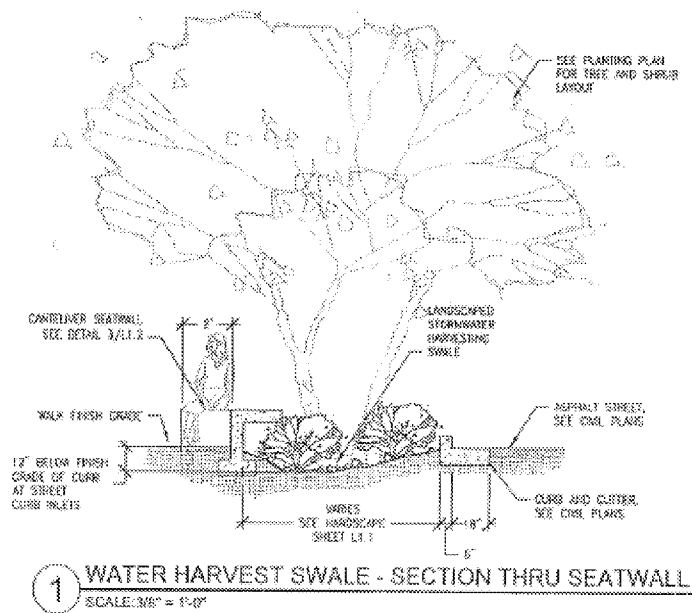


Figure 28: Taylor Mall Site Plan



Figure 29: Central Station/Civic Space (after)



Figure 30: Taylor Mall (After)

Table 28: Central/Civic/Taylor GI/LID Inputs: Shrubs

	Unit	Expected Value
Name of feature		Shrubs
New or existing?		New
Number of new shrubs being planted	#	680
Area of new shrubs being planted	Acre	-
Soil type	Choice	B
Shrubs Average Expected Lifespan	Year	8.5
Shrubs Max Expected Lifespan	Year	10
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$9,280 (Low = \$4,640, High = \$15,081)
Annual O&M	\$	-

Notes:

- O&M included as part of O&M costs of other features.

Table 29: Central/Civic/Taylor GI/LID Inputs: Pervious Pavers

	Unit	Expected Value
Name of feature		Pervious Paver
Area	Sq ft	51,960
New or existing?		New
Depth of Coverage Materials	Inches	3.5
Percent Empty Space in Material	%	20
Rate of Gray Discharge from Outlet of Feature	-	-
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$673,921 (Low = \$391,778, High = \$924,888)
Annual O&M	\$	\$1,253 (Low = \$626, High = \$2,505)

Notes:

- CapEx of \$12.97 per 1 sq ft was found using Taylor Mall 100% Plan Cost Model. Low and High from SUSTAIN
- O&M costs are based off \$12/1,000 sq ft for power washing costs for porous concrete at Glendale Park and Ride for FY 2017. Low = 1 wash, Expected = 2 washes, High = 4 washes.

Table 30: Central/Civic/Taylor GI/LID Inputs: Swale

	Unit	Expected Value
Name of feature		Swale
Area	Sq ft	13,070
New or existing?		New
Maximum Ponding/Treatment Depth	Inches	12
Channel Bank Height	Inches	12
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$72,238 (Low = \$14,686, High = \$148,455)
Annual O&M	\$	\$1,581 (Low = \$1,265, High = \$1,976)

Notes:

- CapEx: Swale cost taken from 2nd-3rd st site plans, which was 1,717 sq ft and then scaled to 13,070 sq ft to encompass all swales constructed as part of this project.
- CapEx: Low = Includes 1 tree, 8 shrubs, 8 feet of curb cuts per 1,000 sq ft. Does not include concrete removal or the concrete single curb. Expected = Does not include concrete removal. Includes concrete single curb, 2 trees, 16 shrubs, 16 feet of curb cuts per 1,000 sq ft. High = Includes concrete removal, concrete single curb, 3 trees, 26 shrubs, 24 feet of curb cuts (8 openings, 3' each) per 1,000 sq ft.
- O&M: WMG estimates at \$120/1,000 sq ft at \$75 per hour labor cost.

Table 31: Central/Civic/Taylor GI/LID Inputs: Tree Planter

	Unit	Expected Value
Name of feature		Tree planter
Area	Sq ft	1,600
New or existing?		New
Storage volume	Cubic feet	2,925
Depth of Coverage Materials	Inches	12
Percent Empty Space in Material	%	30
Capital Expenditure	\$	\$12,800 (Low = \$880, High = \$39,200)
Annual O&M	\$	\$194 (Low = \$155, High = \$242)

Notes:

- CapEx = Expected, Low, and High values from National Stormwater Management Calculator
- O&M: WMG estimates at \$120/1,000 sq ft at \$75 per hour labor cost.

Table 32: Central/Civic/Taylor GI/LID Inputs: Porous Concrete

	Unit	Design case
Name of feature		Porous concrete
Area	Sq ft	29,826
New or existing?		New
Depth of Coverage Materials	Inches	4
Percent Empty Space in Material	%	20
Rate of Gray Discharge from Outlet of Feature	-	0
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$208,782 (Low = \$190,000, High = \$318,000)
Annual O&M	\$	\$719 (Low = \$359, High = \$1,438)

Notes:

- CapEx: Expected = Site specific cost from the line items taken from Central Station Upgrades. Low and High values taken from SUSTAIN.
- O&M costs are based off \$12/1,000 sq ft for power washing costs for porous concrete at Glendale Park and Ride for FY 2017. Low = 1 wash per year, Expected = 2 times per year, High = 4 times per year.

Table 33: Central/Civic/Taylor GI/LID Inputs: Trees

	Unit	Expected Value
Name of feature		Additional Trees
New or existing?		New
Number of new trees being planted	#	243
Area of new trees being planted	Acre	-
Soil type		B
Maximum Surface Infiltration Rate	Inches per hour	4.5
Minimum Surface Infiltration Rate	Inches per hour	0.25
Infiltration Rate Reduction Factor	per hour	1
Capital Expenditure	\$	\$143,530 (Low = \$38,858, High = \$179,413)
Annual O&M	\$	\$3,798 (Low = \$2,841, High = \$4,763)

Notes:

CapEx: \$591.00 per tree. Mean amount per tree taken from Taylor Mall 100% Plan Model. Low = SUSTAIN, High = Local +25%

O&M: \$15.60 per tree. Watershed Management Group at \$100 per hour and assuming each tree is 9 square meters. Low/High = +/- 25%.

Table 34: Central/Civic/Taylor GI/LID Inputs: Underground Stormwater Storage

	Unit	Expected Value
Name of feature		Underground stormwater storage
Storage volume	Cubic feet	9,587
New or existing?		New
Surface Area Draining into feature	Acres	2.3
Expected outflow when filled	Cubic feet/hr	0
Capital expenditure	\$	\$11,550 (Low = \$8,662, High = \$14,437)
Annual O&M	\$	\$13 (Low = \$5, High = \$60)

Notes:

- CapEx: Site plans for Civic Space Park. High/Low = +/- 25%
- O&M: SUSTAIN

Table 35: Central/Civic/Taylor GI/LID Inputs: New Retention Basin

	Unit	Design case
Name of feature		Retention basin
Area	Acre	0.33
New or existing?		New
Maximum Ponding/Treatment Depth	Inches	12
Rate of Gray Discharge from Outlet of Feature	-	-
Minimum Permanent Depth	Inches	12
Capital Expenditure	\$	\$166,029 (Low = \$61,237, High = \$326,452)
Annual O&M	\$	\$431 (Low = \$216, High = \$862)

Notes:

- CapEx = \$4,260 per cu ft and includes excavation and landscaping.
- CapEx and O&M are from the National Stormwater Management Calculator.

Table 36: Central/Civic/Taylor GI/LID Inputs: Existing Retention Basin

	Unit	Expected Value
Name of feature		Retention basin
Area	Acre	0.145
New or existing?		Existing
Maximum Ponding/Treatment Depth	Inches	36
Rate of Gray Discharge from Outlet of Feature	-	-
Minimum Permanent Depth	Inches	36

Notes:

- This already exists on the site so there is no incremental cost with this.

5 Triple Bottom Line Net Present Value Results (Case Study Sites)

This Section provides an overview of the results of the three case study sites. Dollar amounts reflect costs and benefits estimated for the full 50-year time horizon. The Central/Civic/Taylor inputs were based on design plans and cost estimates – not as-built or invoices, however feature sizes were verified by ground truthing. The tables and graphs that follow show the total cost of ownership of each site, along with the social and environmental benefits that are generated over the 50-year time horizon. Negative numbers represent a cost or disbenefit (financial, social, or environmental), whereas positive numbers illustrate a saving or benefit – the larger the number, the greater the cost or benefit.

5.1 Summary of Results

A summary of the financial, social, and environmental impacts for each case study site are given in Table 37. Results indicate that Primera Iglesia and Glendale Community Center each generate positive TBL-NPV (\$54,600 and \$67,500, respectively) over 50 years, while Central Station/Civic Space Park/Taylor Mall is estimated to have a negative TBL-NPV of around -\$170,000.

We can see that each project generates large social and environmental benefits. Primera Iglesia creates around \$65,000 and \$15,000, respectively, Glendale Community Center creates \$90,000 and \$16,000, and Central/Civic/Taylor generates around \$408,000 and \$435,000 in social and environmental benefits.

It is important to remember that for Primera Iglesia and Glendale Community Center, the base case was a do-nothing (i.e. no cost) scenario; the land cover would have remained the same at no cost. If these sites were to have replaced their land cover with newly built non-GI/LID features, the financial results may have looked more favourable toward LID. The base case for Central/Civic/Taylor was new concrete i.e. new concrete would have been laid down instead of GI/LID. Despite this base case being new concrete (thus incurring a CapEx) and other required features, the financial cost of GI/LID on this project was still significantly higher.

Table 37: Summary of Triple Bottom Line Results Compared to Base Case

	Primera Iglesia	Glendale Community Center	Central/Civic/Taylor
Financial	-\$26,286	-\$38,455	-\$1,014,293
Social	\$65,879	\$89,866	\$408,123
Environmental	\$15,019	\$16,053	\$435,336
Triple Bottom Line NPV	\$54,612	\$67,464	-\$170,834

5.2 Detailed Results

Table 38 breaks down the results for the sites by each impact type. For a more detailed breakdown of the results, which include the 95% confidence intervals for each cost and benefit, please refer to the sections that follow. The purpose of this table is not to compare one site against another, given the different features implemented, their locations, and size of projects, but to help understand where value is being generated or lost for each project.

In terms of financial impacts, it is clear that CapEx is a large driver within all projects. However, O&M actually outweighs CapEx in Primera Iglesia and Glendale Community Center. Another key takeaway from this table is the replacement costs (see methodology section 8.3.1.3), which are significant cost factors – coming in at about half as much as CapEx. If these were to be lower in practice than the expected ones estimated here (perhaps due to good upkeep and maintenance), then the projects would look more favourable on a pure financial basis.

Socially, we see the biggest driver of benefits comes from heat island effect. Given future temperature predictions for Maricopa County under RCP8.5, even small reductions in temperature from shading and vegetation will generate significant heat risk mortality benefits. Flood risk attenuation is the second key driver for social impacts, arising from the improved infiltration resulting from GI/LID.

In terms of environmental factors, we can see that water quality benefits from reduced runoff create significant value. Avoided concrete use in the Central/Civic/Taylor site is also a key benefit driver. Finally, we can see that each site generates benefit from carbon emissions and air pollution due to vegetation and avoided energy use.

Table 38: TBL-NPV Results for Each Feature by Impact Type

Impact Type	Cost/Benefit	Primera Iglesia	Glendale Community Center	Central/Civic/Taylor
Financial	Capital Expenditures	-\$8,863	-\$14,226	-\$576,502
Financial	Operations and Maintenance	-\$14,169	-\$18,693	-\$153,037
Financial	CapEx on Additional Detention	\$36	\$46	\$0
Financial	O&M on Additional Detention	\$9	\$12	\$0
Financial	CapEx on Additional Piping	\$769	\$973	\$0
Financial	O&M on Additional Piping	\$114	\$144	\$0
Financial	Replacement Costs	-\$4,850	-\$7,794	-\$333,981
Financial	Residual Value of Assets	\$669	\$1,084	\$49,228
Social	Heat Island Effect (Mortality)	\$59,148	\$78,232	\$333,713
Social	Heat Island Effect (Morbidity)	\$20	\$9	\$598
Social	Flood Risk	\$5,260	\$8,974	\$65,457
Social	Property Value	\$1,451	\$2,650	\$8,354
Environmental	Water quality	\$5,444	\$6,742	\$92,319
Environmental	Carbon Emissions from Concrete	\$0	\$0	\$281,536
Environmental	Air Pollution Reduced by Vegetation	\$6,397	\$6,974	\$31,586
Environmental	Carbon Reduction by Vegetation	\$469	\$378	\$3,114
Environmental	Air Pollution from Energy Use Reduction	\$1,479	\$1,106	\$14,608
Environmental	Carbon Emissions from Energy Use Reduction	\$1,230	\$853	\$12,173
Total:	Triple Bottom Line NPV	\$54,612	\$67,464	-\$170,834

5.3 Primera Iglesia

Primera Iglesia has a TBL-NPV of \$55,000 (95% confidence interval of \$23,653 to \$88,273) over 50 years and creates around \$66,000 and \$15,000 in social and environmental benefits, respectively. Diving deeper into the results, we see that O&M is the largest driver within the financial impacts at around - \$14,000 over 50 years. However, in terms of social benefits, the tree coverage and LID features generate significant heat island reduction benefits (\$59,000), and flood risk reduction (\$5,300). There are positive environmental benefits, with around \$5,400 through improved water quality, and \$9,600 in reduced carbon emissions and air pollution through vegetation and avoided energy use.

Looking at the confidence intervals in Table 39, we can see that there is a fairly tight spread within the financial impacts, suggesting they have less uncertainty surrounding them. The most uncertainty is around heat island effect (\$41,178 to \$78,135) and water quality (\$920 to \$11,288). When all impacts have been assessed it creates a large spread in overall TBL-NPV of \$23,653 to \$88,273, but even the low estimate creates a positive TBL-NPV.

Financial	Social	Environmental
-\$26,286	\$65,879	\$15,019
Triple Bottom Line NPV		\$54,612

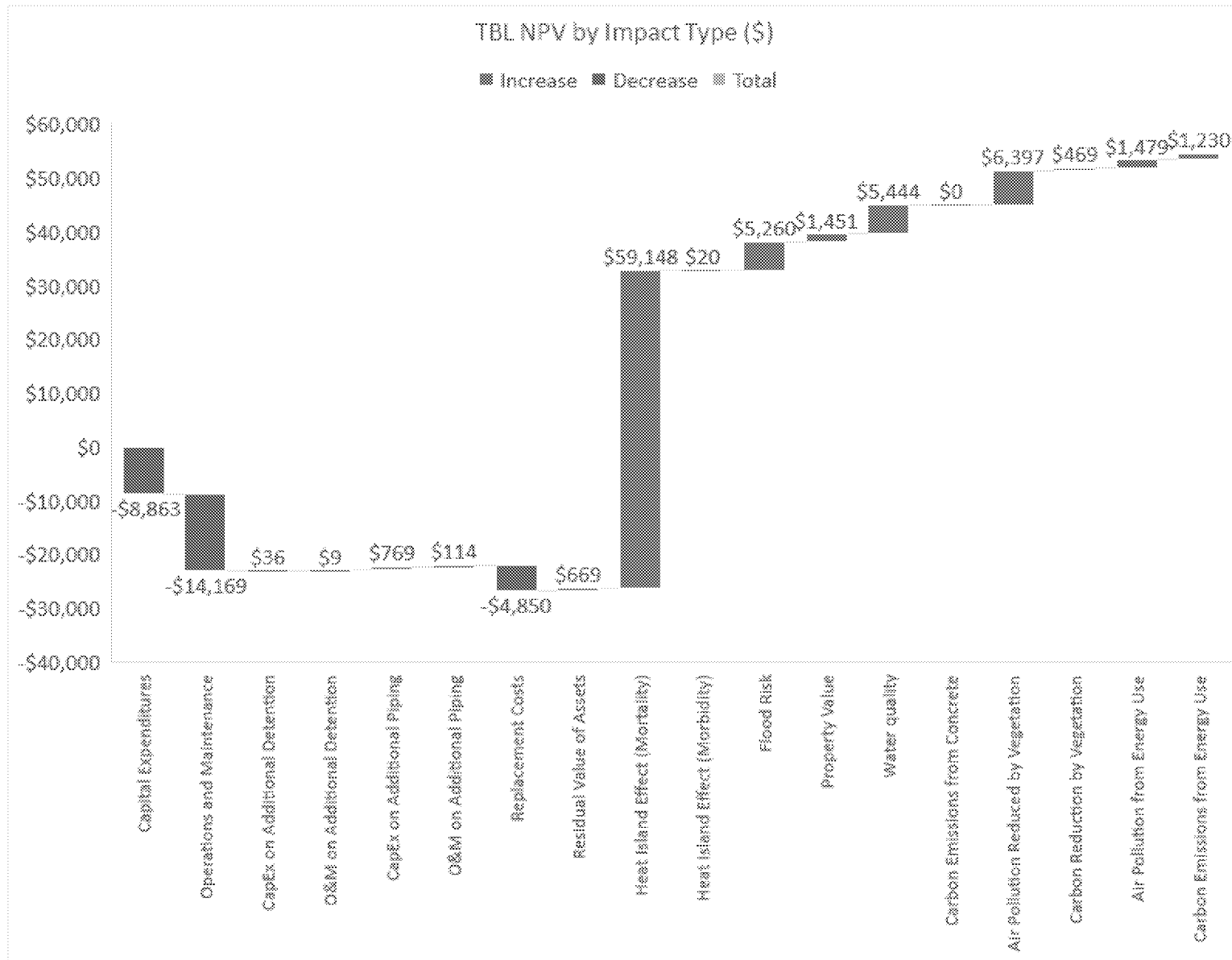


Figure 31: Breakdown of TBL NPV by Impact Type for Primera Iglesia

Table 39: TBL-NPV Results for Each Feature by Impact Type, Primera Iglesia

Impact Type	Cost/Benefit	Mean Value	95% Confidence Interval		
Financial	Capital Expenditures	-\$8,863	-\$8,863	to	-\$8,863
Financial	Operations and Maintenance	-\$14,169	-\$16,506	to	-\$12,117
Financial	CapEx on Additional Detention	\$36	\$12	to	\$60
Financial	O&M on Additional Detention	\$9	\$0	to	\$17
Financial	CapEx on Additional Piping	\$769	\$620	to	\$988
Financial	O&M on Additional Piping	\$114	\$69	to	\$172
Financial	Replacement Costs	-\$4,850	-\$6,114	to	-\$3,597
Financial	Residual Value of Assets	\$669	\$501	to	\$841
Social	Heat Island Effect (Mortality)	\$59,148	\$41,178	to	\$78,135
Social	Heat Island Effect (Morbidity)	\$20	\$20	to	\$20
Social	Flood Risk	\$5,260	\$5,260	to	\$5,260
Social	Property Value	\$1,451	\$944	to	\$1,987
Environmental	Water quality	\$5,444	\$920	to	\$11,288
Environmental	Carbon Emissions from Concrete	\$0	\$0	to	\$0
Environmental	Air Pollution Reduced by Vegetation	\$6,397	\$4,107	to	\$8,651
Environmental	Carbon Reduction by Vegetation	\$469	\$184	to	\$851
Environmental	Air Pollution from Energy Use Reduction	\$1,479	\$868	to	\$2,220
Environmental	Carbon Emissions from Energy Use Reduction	\$1,230	\$454	to	\$2,360
Total	Triple Bottom Line NPV	\$54,612	\$23,653	to	\$88,273

5.4 Glendale Community Center

Glendale Community Center has a TBL-NPV of \$67,000 (95% confidence interval of \$30,804 to \$107,469) over 50 years and creates around \$106,000 in social and environmental benefits. Breaking down the results, we see that O&M costs (-\$18,700) and CapEx (-\$14,200) are the main drivers of the negative financial results. In terms of social benefits, the tree coverage and LID features generate significant heat island reduction benefits (\$78,000) and flood risk reduction (\$9,000). There are positive environmental benefits, with around \$6,700 through improved water quality, and \$9,300 in reduced carbon emissions and air pollution through vegetation and avoided energy use.

Looking at the confidence intervals in Table 40, we can see that there is a fairly tight spread within the financial impacts, suggesting they have less uncertainty surrounding them. The most uncertainty is around heat island effect (\$54,463 to \$103,344) and water quality (\$1,139 to \$13,978). When all impacts have been assessed it creates a large spread in overall TBL-NPV of \$27,370 to \$109,919, but even the low estimate creates a positive TBL-NPV over 50 years.

Financial	Social	Environmental
-\$38,455	\$89,866	\$16,053
Triple Bottom Line NPV		\$67,464

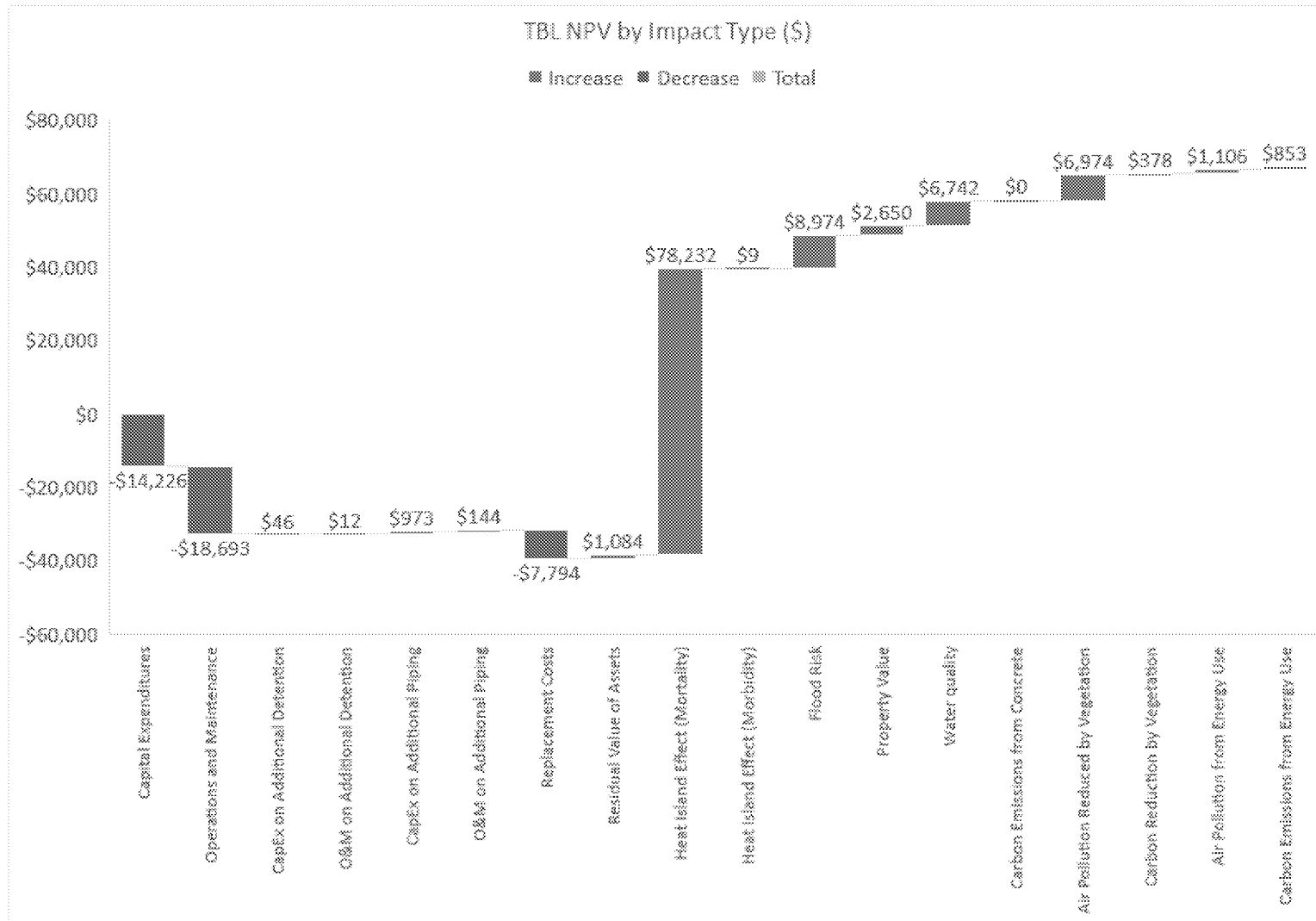


Figure 32: Breakdown of TBL NPV by Impact Type for Glendale

Table 40: TBL-NPV Results for Each Feature by Impact Type, Glendale Community Center

Impact Type	Cost/Benefit	Mean Value	95% Confidence Interval		
Financial	Capital Expenditures	-\$14,226	-\$14,226	to	-\$14,226
Financial	Operations and Maintenance	-\$18,693	-\$22,127	to	-\$16,243
Financial	CapEx on Additional Detention	\$46	\$15	to	\$76
Financial	O&M on Additional Detention	\$12	\$0	to	\$22
Financial	CapEx on Additional Piping	\$973	\$785	to	\$1,252
Financial	O&M on Additional Piping	\$144	\$88	to	\$218
Financial	Replacement Costs	-\$7,794	-\$9,951	to	-\$5,635
Financial	Residual Value of Assets	\$1,084	\$788	to	\$1,374
Social	Heat Island Effect (Mortality)	\$78,232	\$54,463	to	\$103,344
Social	Heat Island Effect (Morbidity)	\$9	\$9	to	\$9
Social	Flood Risk	\$8,974	\$8,974	to	\$8,974
Social	Property Value	\$2,650	\$1,660	to	\$3,645
Environmental	Water quality	\$6,742	\$1,139	to	\$13,978
Environmental	Carbon Emissions from Concrete	\$0	\$0	to	\$0
Environmental	Air Pollution Reduced by Vegetation	\$6,974	\$4,615	to	\$9,306
Environmental	Carbon Reduction by Vegetation	\$378	\$147	to	\$703
Environmental	Air Pollution from Energy Use Reduction	\$1,106	\$660	to	\$1,534
Environmental	Carbon Emissions from Energy Use Reduction	\$853	\$332	to	\$1,587
Total	Triple Bottom Line NPV	\$67,464	\$27,370	to	\$109,919

5.5 Central Station/Civic Space Park/ Taylor Mall

Central Station/Civic Space Park/Taylor Mall has an overall TBL-NPV of -\$170,000 (95% confidence interval of -\$1,552,617 to \$1,314,054) over 50 years but creates almost \$850,000 in social and environmental benefits. The increased cost of implementing the extensive LID features (mainly CapEx from 51,960 square feet of Pervious pavers [\$675,000] and 29,826 square feet of Porous concrete [\$210,000]) compared to a Concrete alternative results in the negative TBL NPV. Breaking down the results, we see that O&M costs (-\$153,000), CapEx (-\$576,000), and Replacement Costs (-\$334,000) are the force behind the negative TBL NPV results. In terms of social benefits, the tree coverage and LID features generate heat island reduction benefits (\$333,000), and flood risk reduction (\$65,000). There are positive environmental outcomes, with around \$92,000 generated through improved water quality, \$282,000 in avoided cost of using concrete, and \$61,000 in reduced carbon emissions and air pollution through vegetation and avoided energy use.

Looking at the confidence intervals in Table 41, we can see that there is a significant spread within CapEx (-\$915,078 to -\$253,456) and Replacement costs (-\$617,912 to -\$41,247), suggesting they have less certainty surrounding them. There is also large uncertainty around heat island effect (\$114,609 to \$558,548) and water quality (-\$48,719 to \$255,721). When all impacts have been assessed it creates a large spread in overall TBL-NPV of -\$1,552,617 to \$1,314,054, suggesting that there is a good chance that the site could generate either a positive or negative TBL-NPV.

Financial	Social	Environmental
\$1,014,293	\$408,123	\$435,336
Triple Bottom Line NPV		-\$170,834

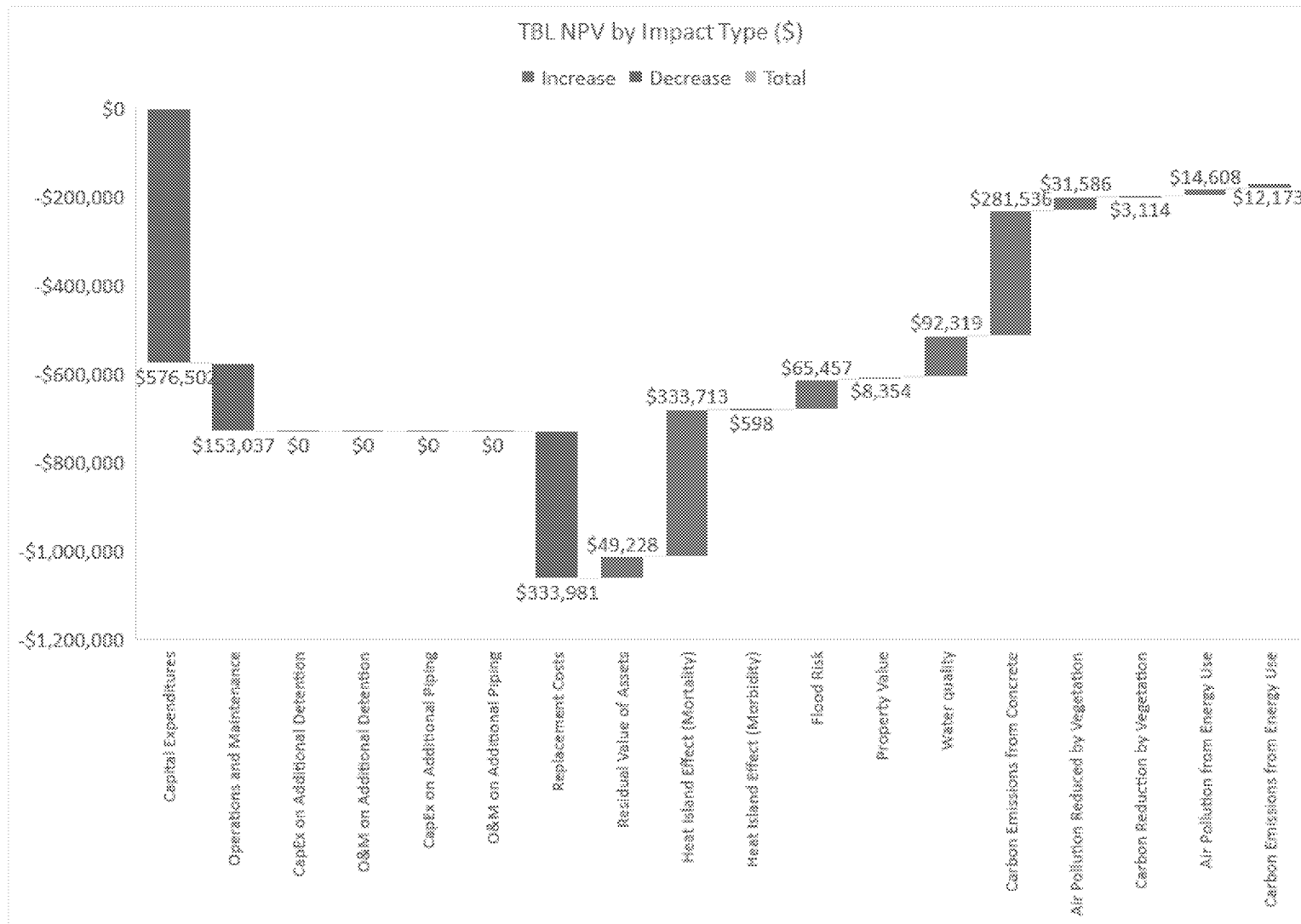


Figure 33: Breakdown of TBL NPV by Impact Type for Central/Civic/Taylor